

RATES OF SPACE WEATHERING IN LUNAR REGOLITH GRAINS. S. Zhang¹ and L. P. Keller². ¹Texas Material Institute, Univ. Texas, Austin, TX 78712. szhang@mail.utexas.edu. ²Robert M. Walker Laboratory for Space Science, ARES, NASA/JSC, Houston, TX 77058.

Introduction: While the processes and products of lunar space weathering are reasonably well-studied, their accumulation rates in lunar soils are poorly constrained. Previously, we showed that the thickness of solar wind irradiated rims on soil grains is a smooth function of their solar flare particle track density, whereas the thickness of vapor-deposited rims was largely independent of track density [1]. Here, we have extended these preliminary results with data on additional grains from other mature soils.

Experimental: Aliquots of the <20 μm fraction of mature highland soil 61181 and mare soil 10084 were embedded in low viscosity epoxy and thin sections were prepared using ultramicrotomy. Anorthite grains were selected for study because: 1) their abundance and lack of complicating microstructures making track imaging relatively straightforward and 2) the track production rate in anorthite is well calibrated [2]. We measured track densities and rim thicknesses in ~100 randomly selected anorthite grains using a JEOL 2010F 200kV field-emission, scanning and transmission electron microscopy (STEM) at UT-Austin and JEOL 2500 STEM at JSC. Tracks and grain rims were imaged using TEM bright/dark-field techniques. The track density was measured in multiple $0.1\mu\text{m} \times 0.1\mu\text{m}$ regions of a grain in a microtome thin section and then converted to the number of tracks/ cm^2 . Given the grain size of the samples, our observations are limited to grains with track densities $> \sim 10^9/\text{cm}^2$.

Results and Discussion: We use the rim types defined by [3]. The thickness of solar wind irradiated amorphous rims on anorthite grains varies from ~10-100 nm with a mean value at ~50 nm and is relatively uniform around the grains. Vapor deposited rim thicknesses show a wider range, from ~10 to >200 nm, with a similar mean value but a much broader thickness-frequency distribution compared to the irradiated rims. Our data on amorphous rims is consistent with ion damage model calculations [4] showing rim thickness increasing with exposure age until a steady-state is achieved. The vapor-deposited rims do not accumulate gradually, but stochastically, with the deposition occurring in only a few or a single event. Our data indicate that both solar wind irradiated rims and vapor-deposited rims on lunar soil grains accumulate rapidly. The highest observed track densities ($\sim 3 \times 10^{11}/\text{cm}^2$) correspond to minimum surface exposures of $\sim 2.5 \times 10^5$ yrs. Ultimately, grain destruction or deep burial prevent the accumulation of thicker rims and higher track densities.

Our results also have implications for the controversies surrounding asteroidal space weathering. Vernazza et al [5] suggest that solar wind interactions dominate asteroid space weathering on rapid timescales of 10^4 - 10^6 years, while others implicate impact processing over much longer time periods (10^8 - 10^9 years) [6]. Our results contradict both of these hypotheses. In immature lunar soils, we showed that vapor-deposition processes dominate over irradiation at the initial stage of space weathering [1].

References: [1] Zhang, S. and Keller, L. P. (2011) *LPSC XVII*, #1947 [2] Blanford, G. E. et al. (1975) *PLPSC 6th*, 3557. [3] Keller, L. P. and McKay, D. S. (1997) *GCA*, 61, 2331. [4] Chamberlin, S. et al. (2008) *LPSC XXXIX*, #2302. [5] Vernazza, P. et al. (2009) *Nature* 458, 993. [6] Willman, M. et al. (2010) *Icarus* 208, 758.